Alternative Green Biocatalysts to Induce Carbonate Precipitation for Applications on Building Materials

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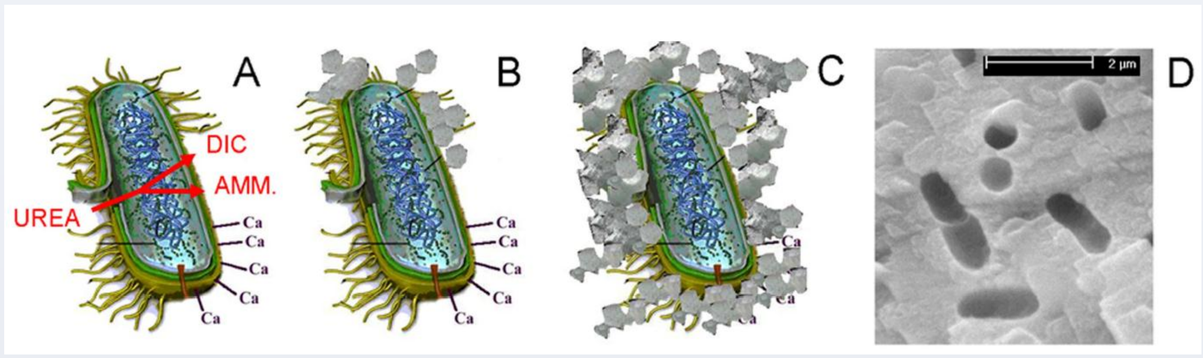
Research Background

MICROBIALLY INDUCED CARBONATE PRECIPITATION (MICP)

- Specific bacteria (e.g., *Bacillus sphaericus*) act as biocatalysts to degrade **urea** to **ammonium** and **carbonate** producing **ammonium chloride** and **calcium carbonate** crystals where bacteria act as nucleation sites



pHD thesis Willem De Muynck, 2009

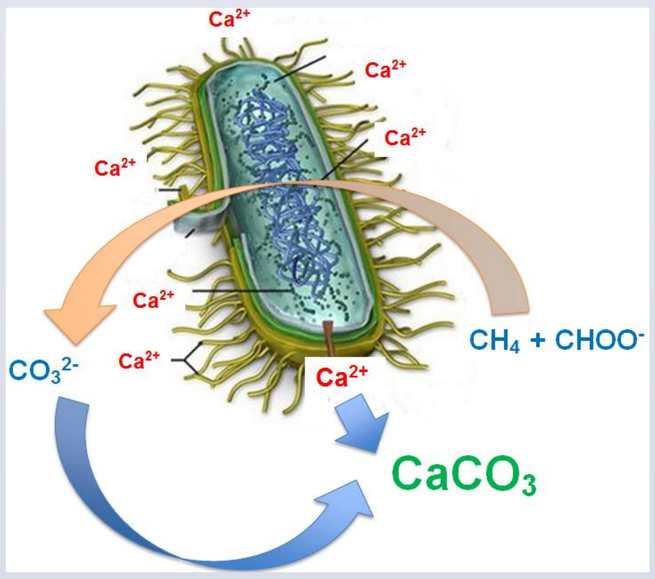
- Applications in construction industries: **(1) Concrete surface treatments and (2) Self-healing concrete**

Problem statements:

(1) Environmental pollutions due to the release of ammonia to the atmosphere
(2) Unwanted by-products (i.e., ammonium chloride) which damages concrete

Alternative solution

- **Methane-Oxidizing Bacteria (MOB)** are capable to produce carbonate ions from **methane** and **formate**. The high pH environment needed to precipitate calcium carbonate would arise from the conversion of formate to carbonate



- Advantages:
  - ✓ Removal of greenhouse gas (i.e., methane) from the air
  - ✓ No by products that can damage the concrete or the environment

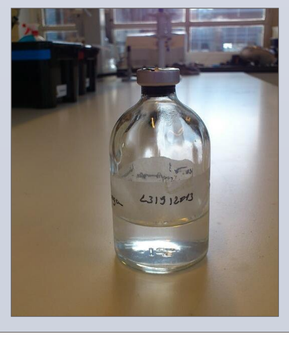
Research goal:

To investigate the capability of MOB to precipitate calcium carbonate from methane and calcium formate

Materials and Methods

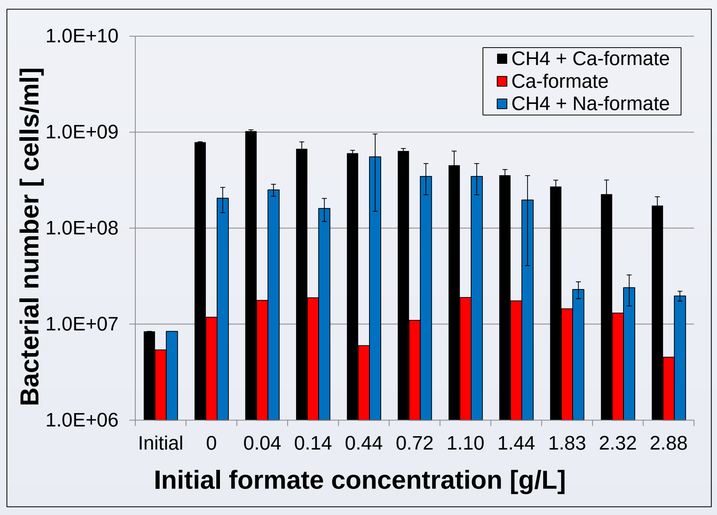
- 4 days liquid incubation of MOB under methane/air atmosphere at 28°C and calcium formate addition at different concentrations

MOB strain	***Methylocystis parvus***
Methane/air	20 % (v/v)
Formate (g/L)	0 – 2.88
Analysis	• Methane removal • $CaCO_3$ precipitation • Formate removal • Bacterial growth

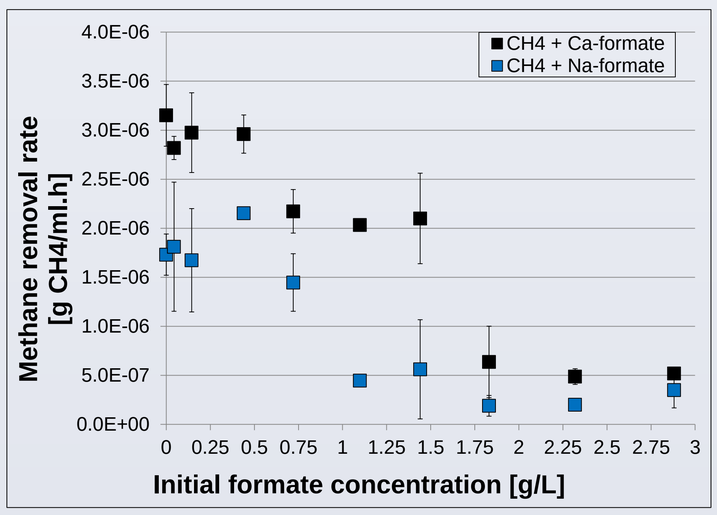


Results

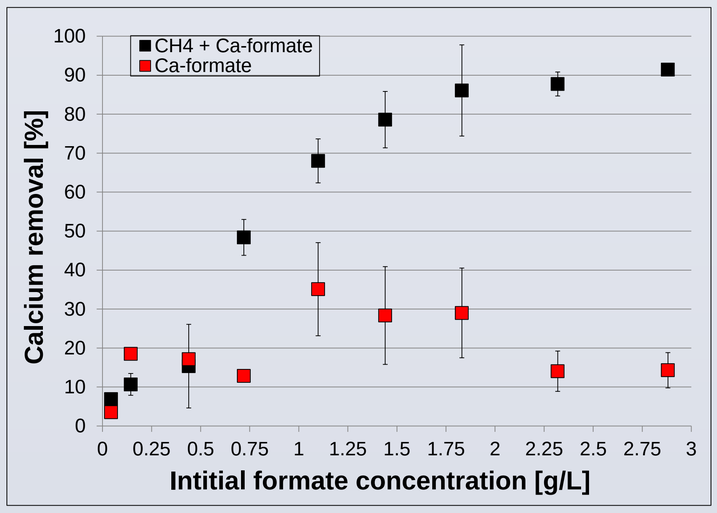
The following are the results after 4 days of incubation of MOB with : **(a) methane and calcium formate (b) calcium formate only (c) methane and sodium formate**



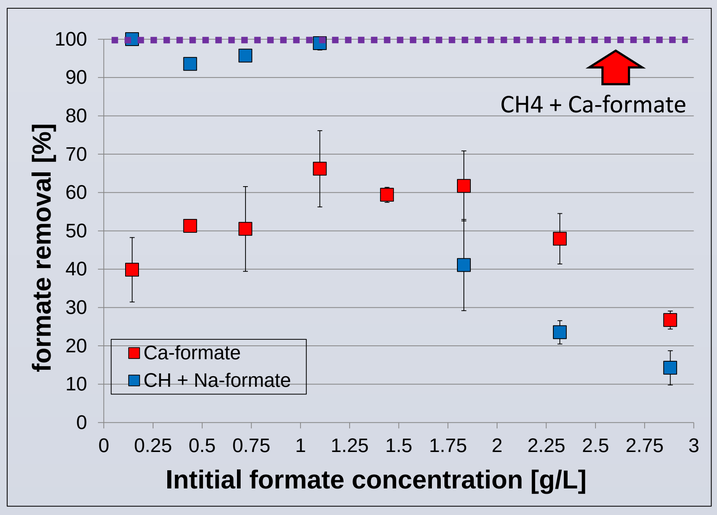
- Methane increased the bacterial growth
- A high formate addition inhibited bacterial growth



- Lower methane removal rate when bacteria were incubated with sodium formate due to the lower number of bacteria
- A high formate addition decreased the methane removal by the bacteria



- Higher calcium carbonate precipitated for incubation with methane due to the higher number of bacteria
- Higher calcium removal at increasing formate concentrations



- Lower formate removal at high formate concentration due to the death of bacteria caused by calcium carbonate crystal formation around cells and toxicity

Conclusion:

A more environmentally friendly biocatalyst to precipitate calcium carbonate is found with MOB using methane and calcium formate as substrates

Research perspective

- Possible applications:
  - ✓ Surface treatment of concrete-based building in areas with high methane emissions (e.g., animal houses, cities)

Acknowledgements

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